Section 2

Climate Regions

Objectives

After this lesson, students will be able to

I.4.2.1 Identify factors used to define climates.

I.4.2.2 Describe the six main climate regions.

Target Reading Skill

Comparing and Contrasting Explain that comparing and contrasting information shows how ideas are similar and different.

Answers

Possible answers:

Tropical rainy: Hot

Dry: Little rainfall; Hot or cold

Temperate marine: Dry to rainy, depending on season and location; Cool to hot, depending on season and location

Temperate continental: Light to moderate rainfall; Cold to hot, depending on season and location

Polar: Dry; Cold

Highlands: Wetter than nearby lowlands; Cooler than nearby lowlands

All in One Teaching Resources

- Transparency I43

Preteach

Build Background Knowledge

Different Climate Types L2

Ask students to describe places to which they have traveled or that they have read about. Elicit details about the climate and the kinds of plants and animals. Challenge students to compare the climates, plants and animals of these places with those at home. **learning modality: verbal**

Section 2

Climate Regions

Reading Preview

Key Concepts

- What factors are used to classify climates?
- What are the six main climate regions?

Key Terms

- rain forest • savanna
- desert • steppe
- humid subtropical • subarctic
- tundra • permafrost

Target Reading Skill

Comparing and Contrasting

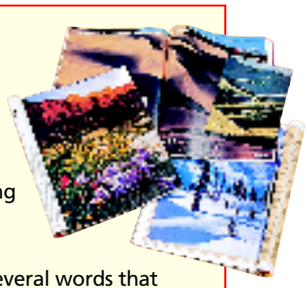
As you read, compare and contrast the six main climate regions by completing a table like the one below.

Climate Regions

Climate Region	Precipitation	Temperature
Tropical Rainy	Heavy precipitation	
Dry		
Temperate Marine		

Lab zone Discover Activity

How Do Climates Differ?



1. Collect pictures from magazines and newspapers of a variety of land areas around the world.
2. Sort the pictures into categories according to common weather characteristics.

Think It Over

Forming Operational Definitions Choose several words that describe the typical weather for each category. What words would you use to describe the typical weather where you live?

Suppose you lived for an entire year near the equator. It would be very different from where you live now. The daily weather, the amount of sunlight, and the pattern of seasons would all be new to you. You would be in another climate region.

Scientists classify climates according to two major factors: temperature and precipitation. They use a system developed around 1900 by Wladimir Köppen (KEP un). Besides temperature and precipitation, Köppen also looked at the distinct vegetation in different areas. This system identifies broad climate regions, each of which has smaller subdivisions.

There are six main climate regions: tropical rainy, dry, temperate marine, temperate continental, polar, and highlands. These climate regions are shown in Figure 10.

Maps can show boundaries between the climate regions. In the real world, of course, no clear boundaries mark where one climate region ends and another begins. Each region blends gradually into the next.

Lab zone Discover Activity

Skills Focus Forming operational definitions L1

Materials newspapers or discarded magazines, scissors

Time Prep: 10 minutes (to collect newspapers and magazines); Class: 15 minutes

Tips To save class time, assign students to collect magazine pictures for homework or provide the pictures yourself. Before students look at the pictures, encourage them to list some characteristics of various climates.

Expected Outcome Pictures should be sorted into categories such as desert, rain forest, mountain, and dry prairie. However, students might sort the pictures on the basis of other climate factors.

Think It Over Accept all answers that are based on some logical classification system. Some students might use actual climate names to describe their pictures.

Tropical Rainy Climates

The tropics have two types of rainy climates: tropical wet and tropical wet-and-dry. Tropical wet climates are found in low-lying lands near the equator.

Tropical Wet In areas that have a tropical wet climate, many days are rainy, often with afternoon thunderstorms. These thunderstorms are triggered by midday heating. Another source of precipitation is prevailing winds. In many areas with a tropical wet climate, the trade winds bring moisture from the oceans. With year-round heat and heavy rainfall, vegetation grows lush and green. Dense rain forests grow in these rainy tropical climates. **Rain forests** are forests in which large amounts of rain fall year-round. Tropical rain forests are important because it is thought that at least half of the world's species of land plants and animals are found there.

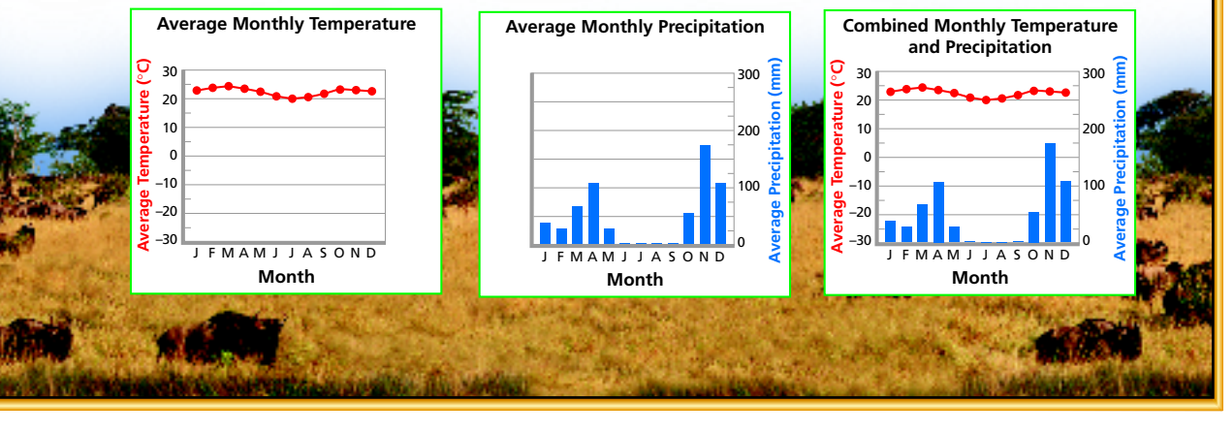
In the United States, only the windward sides of the Hawaiian islands have a tropical wet climate. Rainfall is very heavy—over 10 meters per year on the windward side of the Hawaiian island of Kauai. The rain forests of Hawaii have a large variety of plants, including ferns, orchids, and many types of vines and trees.

FIGURE 8
Tropical Rain Forests
Lush tropical rain forests grow in the tropical wet climate.

Tropical Wet-and-Dry Areas that have tropical wet-and-dry climates receive slightly less rain than tropical climates and have distinct dry and rainy seasons. Instead of rain forests, there are tropical grasslands called **savannas.** Scattered clumps of trees that can survive the dry season dot the coarse grasses. Only a small part of the United States—the southern tip of Florida—has a tropical wet-and-dry climate. The graphs in Figure 9 show how temperature and precipitation vary in Makindu, Kenya, in East Africa.

Reading Checkpoint **What parts of the United States have tropical rainy climates?**

FIGURE 9
Climate Graphs
A graph of average temperature (left) can be combined with a graph of average precipitation (middle) to form a climate graph. These graphs show data for a tropical wet-and-dry region.



Instruct

Tropical Rainy Climates

Teach Key Concepts L2

Tropical Climates

Focus Remind students that the tropics are just north and south of the equator. Ask: **What can you infer about climate in the tropics?** *(Climate will be warm, but rainfall probably will vary.)*

Teach Introduce the two tropical rainy climates: tropical wet and tropical wet-and-dry. Ask: **What would it be like in a tropical wet climate?** *(Warm and humid with frequent showers, abundant plant and animal life in heavy rain forest)* **How do you think a tropical wet-and-dry climate would be different?** *(Wet and dry seasons occur. The land is covered with savannas.)*

Apply Ask: **If you were in Africa and saw a lion chase a zebra from a pond that often dries up, which climate region would you be in?** *(Tropical wet-and-dry)* **learning modality: verbal**

Independent Practice L2

All in One Teaching Resources

- Guided Reading and Study Worksheet: *Climate Regions*
- Transparency I44

Differentiated Instruction

English Learners/Beginning L1
Comprehension: Link to Visual
Have students use index cards and string to make a flip book of the climate regions. Students can write the name and a brief description of each region on each card. Complete the first card for them. Encourage students to add illustrations or words from their first languages to help them understand the terms. **learning modality: visual**

English Learners/Intermediate L2
Comprehension: Link to Visual
Students can do the Beginning activity. Then, have them write sentences in which they use the names of each climate region. **learning modality: verbal**

Monitor Progress L2

Skills Check Have students make a Venn diagram to compare and contrast tropical wet and tropical wet-and-dry climates.

Answers

Reading Checkpoint The windward sides of the Hawaiian Islands

Help Students Read L2

Using Prior Knowledge Students absorb new material more quickly when they can relate it to previously learned concepts. In the previous section, students learned abou the factors that influence precipitation and temperature. Before they read about climat regions, have each of them write a short paragraph that identifies how these factors affect regional climate.

Use Visuals: Figure 10 L

The Six Main Climate Regions

Focus Refer students to Figure 10. Point ou that the color-coded map and the descriptions include six main climates, which are subdivided into 12 climate types.

Teach Allow students time to study the maj and key. Then ask: **What do you notice about the pattern of climates on the map?** *(Warmer climates occur at low latitude, colde climates occur at high latitude; moist climate often are near the ocean, dry climates often ar inland)* Challenge students to explain these patterns. *(Sunlight strikes Earth at a greater angle near the equator. Prevailing winds ofte bring moist air masses to coastal regions; dry winds blow over deserts or where a rain shadow exists.)*

Apply Ask: **How could a cool climate region exist at low latitude?** *(It would have to be a highland climate.)* **learning modality: visual**

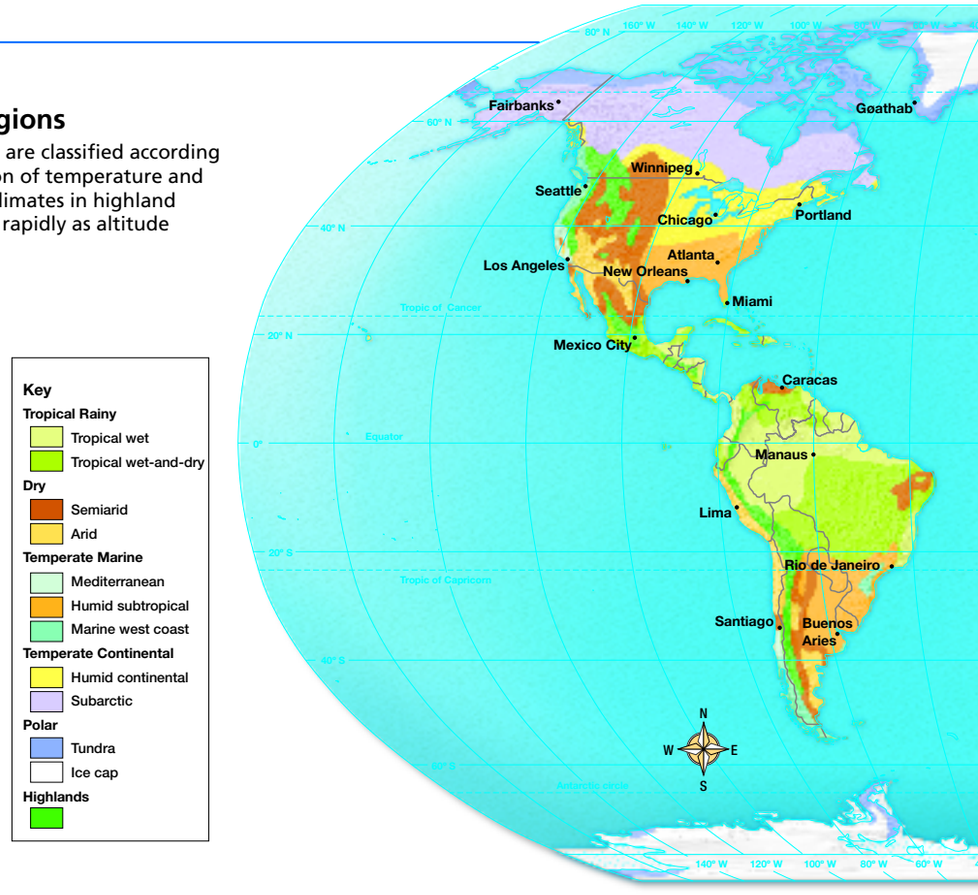
All in One Teaching Resources

- Transparencies I45

FIGURE 10

Climate Regions

Climate regions are classified according to a combination of temperature and precipitation. Climates in highland regions change rapidly as altitude changes.



Tropical Rainy
Temperature always 18°C or above

Tropical wet Always hot and humid, with heavy rainfall (at least 6 centimeters per month) all year round

Tropical wet-and-dry Always hot; alternating wet and dry seasons; heavy rainfall in the wet season

Dry
Occurs wherever potential evaporation is greater than precipitation; may be hot or cold

Semiarid Dry but receives about 25 to 50 centimeters of precipitation per year

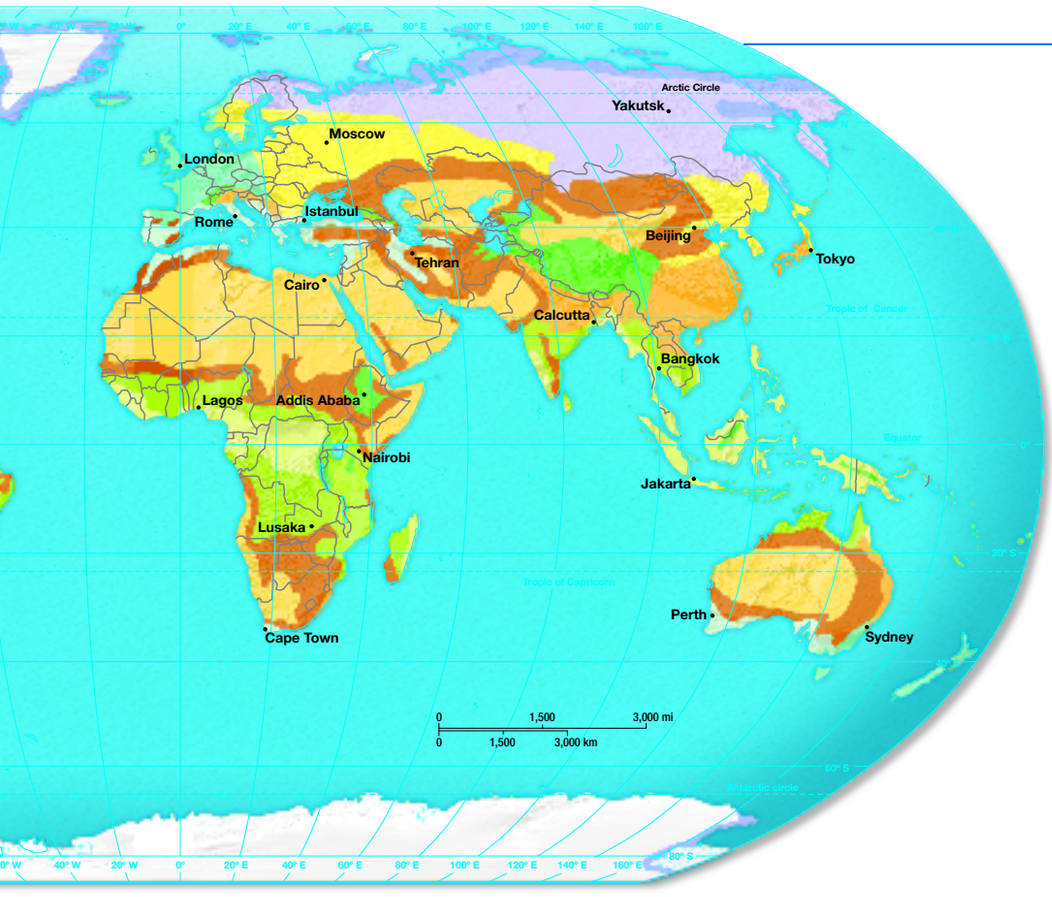
Arid Desert, with little precipitation, usually less than 25 centimeters per year

Temperate Marine
Averages 10°C or above in warmest month, between –3°C and 18°C in the coldest month

Mediterranean Warm, dry summers and rainy winters

Humid subtropical Hot summers and cool winters

Marine west coast Mild winters and cool summers, with moderate precipitation all year



Temperate Continental
Average temperature 10°C or above in the warmest month, –3°C or below in the coldest month

Humid continental Hot, humid summers and cold winters, with moderate precipitation year round

Subarctic Short, cool summers and long, cold winters; light precipitation, mainly in summer

Polar
Average temperature below 10°C in the warmest month

Tundra Always cold with a short, cool summer—warmest temperature about 10°C

Ice cap Always cold, average temperature at or below 0°C

Highlands

Generally cooler and wetter than nearby lowlands; temperature decreasing with altitude

Lab zone Build Inquiry L2

Describing Climate Regions

Materials reference books, construction paper, lined notebook paper

Time 30 minutes

Focus Explain that travelers need to know the climate of their chosen destination so that they can be prepared for the weather they will encounter.

Teach Divide the class into small groups so that each group has a different climate region. Challenge group members to choose one destination within their region and assemble a travel brochure that describes the destination, its climate, and what travelers can expect to see there. Demonstrate how to fold a piece of construction paper into a tri-fold brochure. Have students write information on lined notebook paper and then cut and glue the paper to the construction paper, which will serve as a background. Encourage students to add illustrations if time permits. Display actual travel brochures as models.

Apply Tell students that it is their job to promote tourism to their destination. Have students show their brochure and try to convince classmates that it is a good place to visit. Students should address climate during their presentation. **learning modality: kinesthetic**

Differentiated Instruction

Less Proficient Readers L1

Remembering Vocabulary Ask students to write key terms on separate index cards. They can write the definitions and any other words, phrases, or illustrations that will help them remember the meanings of the words. Some students might find it helpful to write the phonetic pronunciation of each word.

Special Needs L1

Learning Climate Regions Have students read or speak the names of the different climate regions. After they have examined the names, encourage them to explain how the name of each zone can help a person remember the climate characteristics of that zone. **learning modality: verbal**

Monitor Progress L2

Drawing Have each student draw or trace a map of the United States, including Alaska and Hawaii, and label the major climate zones. Students may place their drawings in their portfolios.

Portfolio

Dry Climates

Teach Key Concepts L2

The Dry Climate Regions

Focus Ask: **What is evaporation?** *(Water changing from liquid into gas)* **What is precipitation?** *(Rain or snow falling to Earth)* Tell students that in dry regions the amount of evaporation that can occur is greater than the amount of precipitation that falls.

Teach Ask: **Why would a region be dry if the amount of potential evaporation was greater than the amount of precipitation?** *(All precipitation that falls could be evaporated. This keeps the soil dry.)* **What do you think determines whether a dry region is arid or semiarid?** *(Arid regions have either or both higher potential evaporation or lower precipitation than semiarid regions.)*

Apply Ask: **How could a desert exist in Antarctica near Earth's South Pole where evaporation is low?** *(The amount of precipitation is very low.)* **Which dry regions would have high potential evaporation?** *(Areas near or in the tropics)* **learning modality: verbal**

Lab zone Build Inquiry L2

Observing Plant Adaptations

Materials cactus plant, jade plant, various grasses, magnifying lens, forceps

Time 20 minutes

Focus Remind students that plants that grow in dry climate regions are highly specialized.

Teach Encourage students to use a magnifying lens to examine all parts of the plants. You can use a scalpel or razor blade to slice some cross-sections of leaves, stems, and roots. Have students describe their observations.

Apply Ask: **How are dry-region plants adapted to the climate?** *(The plants have structures for preventing water loss, such as thick, waxy coverings and roots that spread over a large area just below the surface.)* **learning modality: visual**

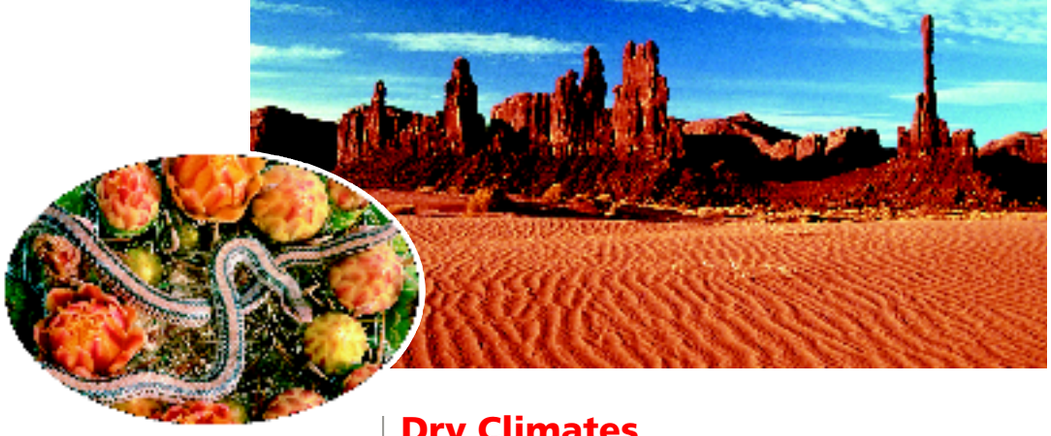
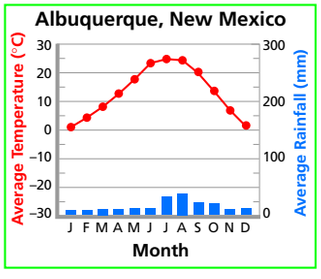


FIGURE 11
Arid Climate
Deserts of the southwestern United States are home to the western patchnose snake.
Interpreting Graphs *Which month has the highest average temperature?*



Dry Climates

A climate is "dry" if the amount of precipitation that falls is less than the amount of water that could potentially evaporate. Because water evaporates more slowly in cool weather, a cool place with low rainfall may not be as dry as a warmer place that receives the same amount of rain. **Dry climates include arid and semiarid climates.**

Look at the map of world climate regions in Figure 10. What part of the United States is dry? Why is precipitation in this region so low? As you can see, dry regions often lie inland, far from oceans that are the source of humid air masses. In addition, much of the region lies in the rain shadow east of the Sierra Nevada and Rocky Mountains. Humid air masses from the Pacific Ocean lose much of their water as they cross the mountains. Little rain or snow is carried to dry regions.

Arid When you think about **deserts,** or arid regions, you may picture blazing heat and drifting sand dunes. Some deserts are hot and sandy, but others are cold or rocky. On average, arid regions, or deserts, get less than 25 centimeters of rain a year. Some years may bring no rain at all. Only specialized plants such as cactus and yucca can survive the desert's dryness and extremes of hot and cold. In the United States there are arid climates in portions of California, the Great Basin, and the Southwest.

Semiarid Locate the semiarid regions in Figure 10. As you can see, large semiarid areas are usually located on the edges of deserts. These semiarid areas are called steppes. A **steppe** is dry but gets enough rainfall for short grasses and low bushes to grow. For this reason, a steppe may also be called a prairie or grassland. The Great Plains are the steppe region of the United States.

Reading Checkpoint **What is a desert?**

Temperate Marine Climates

Look once again at Figure 10, along the coasts of continents in the temperate zones. You will find the third main climate region, temperate marine. **There are three kinds of temperate marine climates: marine west coast, humid subtropical, and mediterranean.** Because of the moderating influence of oceans, all three are humid and have mild winters.

Marine West Coast The coolest temperate marine climates are found on the west coasts of continents north of 40° north latitude and south of 40° south latitude. Humid ocean air brings mild, rainy winters. Summer precipitation can vary considerably.

In North America, the marine west coast climate extends from northern California to southern Alaska. In the northwestern United States, humid air from the Pacific Ocean hits the western slopes of the Coastal Ranges. The air rises up the slopes of the mountains, and it cools. As the air cools, large amounts of rain or snow fall on the western slopes. The eastern slopes lie in the rain shadow of the mountains and receive little precipitation.

Because of the heavy precipitation, thick forests of tall trees grow in this region, including coniferous, or cone-bearing, trees such as Sitka spruce, Douglas fir, redwoods, and Western red cedar, as shown in Figure 12. One of the main industries of this region is harvesting and processing wood for lumber, paper, and furniture.

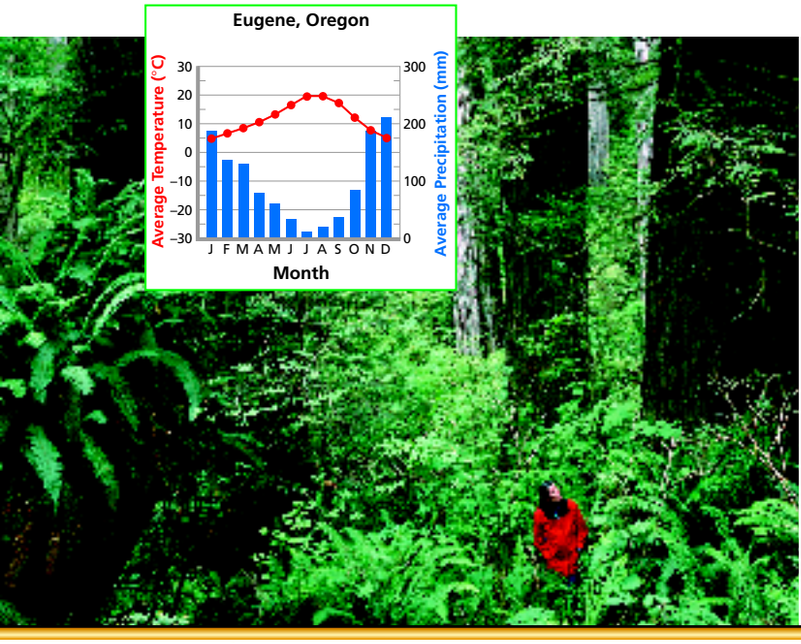


FIGURE 12
Marine West Coast Climate
Redwoods, Douglas firs, and Sitka spruce dominate the lush forests found in marine west coast climates.

Lab zone Try This Activity

Modeling a Climate

Here's how you can create humidity.

1. Put the same amount of water in each of two small plastic bowls.
2. Place a sheet of transparent plastic wrap over each bowl. Secure each sheet with a rubber band.
3. Place one bowl on a warm, sunny windowsill or near a radiator. Put the other bowl in a cool location.
4. Wait a day and then look at the two bowls. What do you see on the plastic wrap over each bowl?

Inferring Would you expect to find more water vapor in the air in a warm climate or in a cool one? Why? Explain your results in terms of solar energy.

Temperate Marine Climates

Teach Key Concepts L2

Types of Temperate Marine Climates

Focus Tell students that temperate marine climate regions occur near oceans. Ask: **How do you think the ocean would affect these climates?** *(It's a source of moisture. It moderates the temperature.)*

Teach Describe for students the locations of each of the temperate climate regions. Then have them identify the climate region that correlates with the following descriptions: **Hot, humid summers** *(humid subtropical)* **Dry summers with little rain** *(Mediterranean)* **cool winters and summers** *(Marine west coast)*

Apply Have students describe types of vegetation in each temperate marine climate. **learning modality: verbal**

Lab zone Try This Activity

Skills Focus Inferring L2

Materials 2 small plastic bowls, water, clear plastic wrap, 2 rubber bands

Time 10 minutes for set up; 5 minutes for later observation

Tips Have students find their own locations for the bowls.

Expected Outcome The plastic wrap over the warm bowl will have more water drops than the plastic wrap over the cool bowl. The air of warm climates often has more water vapor because solar energy warms water and causes it to evaporate into the air.

Extend Instruct students to keep the bowls in the same places but to remove the plastic wrap. Tell them to note which bowl has less water at the end of the week. **learning modality: visual**

Monitor Progress L2

Writing Have students write about dry climate regions. One paragraph should be about arid regions, and a second paragraph should be about semiarid regions.

Answers

Figure 11 July

Reading Checkpoint An arid region that gets less than 25 cm of rain a year

Lab zone Build Inquiry

L2

Making and Interpreting a Climograph

Materials statistics on average high and low temperatures and precipitation for your city or area (this can be obtained from the Internet), daily weather reports

Time 20 minutes to plot the graph; 5 minutes daily for several days

Focus Explain that a climograph is a graph that shows the average precipitation and temperature in an area for each month.

Teach Provide students with the data, and have them make a climograph from the data. Each day over several days, ask students to compare the average daily temperature with those on the climograph. Students also should compare precipitation received with the average amount for the month.

Apply Ask students to explain why there can be differences between the climograph and daily weather. *(Weather varies from day to day and from year to year. The averages represent overall conditions, or climate, over an extended period.)* **learning modality: logical/mathematical**

Integrating Life Science

Explain to students that the chaparral biome, or plant and animal community, is typical of Mediterranean climates. The chaparral is characterized by dense growth of evergreen shrubs and small trees. Chaparral plants have small, thick, waxy leaves. These plants are dormant in the hot, dry summer and come to life with the first rainfall in winter. The chaparral is a fire-dependent biome. Fires wipe out dead plant material, recycle nutrients, thin old growth, and stimulate new growth from seeds and sprouts. Chaparral plants have adapted to fire by producing seeds that are either resistant to fire or require fire for germination. Ask: **Considering these adaptations, what can you infer about this region?** *(This region is prone to fires because it is warm and dry during the summer.)*

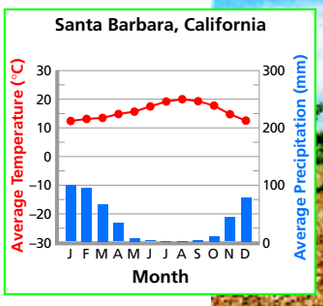


FIGURE 13
Mediterranean Climate
Santa Barbara, on the coast of southern California, has a Mediterranean climate. Mild temperatures throughout the year make the area ideal for growing olives and citrus fruits.
Interpreting Graphs *How much precipitation does Santa Barbara receive in July? In January?*

Mediterranean A coastal climate that is drier and warmer than west coast marine is known as Mediterranean. Most areas with this climate are found around the Mediterranean Sea. In the United States, the southern coast of California has a Mediterranean climate. This climate is mild, with two seasons. In winter, marine air masses bring cool, rainy weather. Summers are somewhat warmer, with little rain.

Mediterranean climates have two main vegetation types. One is made up of dense shrubs and small trees, called chaparral (chap uh RAL). The other vegetation type includes grasses with a few large trees.

Agriculture is important to the economy of California's Mediterranean climate region. Using irrigation, farmers grow many different crops, including rice, many vegetables, fruits, and nuts.

Humid Subtropical The warmest temperate marine climates are along the edges of the tropics. **Humid subtropical** climates are wet and warm, but not as constantly hot as the tropics. Locate the humid subtropical climates in Figure 10.

The southeastern United States has a humid subtropical climate. Summers are hot, with much more rainfall than in winter. Maritime tropical air masses move inland, bringing tropical weather conditions, including thunderstorms and occasional hurricanes, to southern cities such as Houston, New Orleans, and Atlanta. Winters are cool to mild, with more rain than snow. However, polar air masses moving in from the north can bring freezing temperatures and frosts.

Mixed forests of oak, ash, hickory, and pines grow in the humid subtropical region of the United States. Important crops in this region include oranges, peaches, peanuts, sugar cane, and rice.

Reading Checkpoint **What region of the United States has a humid subtropical climate?**

Lab zone Skills Activity

Classifying

The table shows some climate data for three cities.

	City A	City B	City C
Average Jan. Temp. (°C)	12.8	18.9	−5.6
Average July Temp. (°C)	21.1	27.2	20
Annual Precipitation (cm)	33	152	109

Describe the climate you would expect each city to have. Identify the cities of Miami, Florida; Los Angeles, California; and Portland, Maine. Use Figure 10 to help identify each city's climate.

Lab zone Skills Activity

L2

Skills Focus Classifying

Materials Figure 10

Time 10 minutes

Tips Remind students to look back to Figure 10 for help.

Expected Outcome City A is Los Angeles, which has a Mediterranean climate (warm and dry); City B is Miami, which has a tropical wet-and-dry climate (hot and humid); City C is Portland, Maine, which has a humid continental climate (hot summers and cool winters).

Extend Challenge students to classify the climates of Seattle, Washington, Chicago, Illinois, and Charleston, South Carolina. **learning modality: logical/mathematical**

Temperate Continental Climates

Temperate continental climates are not influenced very much by oceans, so they commonly have extremes of temperature. **Temperate continental climates are only found on continents in the Northern Hemisphere, and include humid continental and subarctic.** The parts of continents in the Southern Hemisphere south of 40° south latitude are not far enough from oceans for dry continental air masses to form.

Humid Continental Shifting tropical and polar air masses bring constantly changing weather to humid continental climates. In winter, continental polar air masses move south, bringing bitterly cold weather. In summer, tropical air masses move north, bringing heat and high humidity. Humid continental climates receive moderate amounts of rain in the summer. Smaller amounts of rain or snow fall in winter.

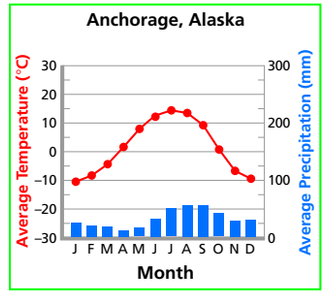
What parts of the United States have a humid continental climate? The eastern part of the region—the Northeast—has a range of forest types, from mixed forests in the south to coniferous forests in the north. Much of the western part of this region—the Midwest—was once tall grasslands, but is now farmland.

Subarctic The **subarctic** climates lie north of the humid continental climates. Summers in the subarctic are short and cool. Winters are long and bitterly cold.

In North America, coniferous trees such as spruce and fir make up a huge northern forest that stretches from Alaska to eastern Canada. Wood products from this forest are an important part of the economy. Many large mammals, including bears and moose, live in the forest. Birds of many species breed in the subarctic.

Reading Checkpoint **Which area of the United States has a subarctic climate?**

FIGURE 14
Subarctic Climate
Subarctic climates have cool summers and cold winters. The world's largest subarctic regions are in Russia, Canada, and Alaska. This emperor goose is breeding in the subarctic climate region in Alaska.



Temperate Continental Climates

Teach Key Concepts L2

Humid Continental and Subarctic Climates

Focus Remind students that continental interiors have high temperature extremes from season to season.

Teach Ask: **What are some examples of continents that have very large interior regions?** *(North America and Asia)* Tell students that continental climates occur on these continents from about 40° latitude to the Arctic. Ask: **How do you think climate would differ between the northern part of this region and the southern part?** *(The northern part would be colder.)* Tell students that this northern part is the subarctic climate zone, and the southern part is the humid continental climate zone.

Apply Have students describe typical summer weather and typical winter weather in each of these zones. **learning modality: visual**

Monitor Progress L2

Skills Check Have students compare and contrast the three types of temperate marine climates.

Answers

Figure 13 In July, less than 5 mm; in January, about 100 mm

Reading Checkpoint The southeastern United States

Reading Checkpoint Much of Alaska

Polar Climates

Go Online SCI LINKS NSTA

For: Links on climates of the world
Visit: www.SciLinks.org
Web Code: scn-0942

Download a worksheet that will guide students' review of Internet resources on climates of the world.

Teach Key Concepts L2

The Coldest Climate Regions

Focus Remind students that polar regions receive sunlight at a sharp angle. Tell them that these regions are very cold for this reason.

Teach Tell students that almost all of Antarctica and Greenland are covered by ice and that ice cap climates exist on top of and around this ice. Ask: **How would you describe an ice cap climate?** *(Cold all year and often bitterly cold)* **Do you think these climates get a lot of snow?** *(Many students will say "yes." Tell them that most ice cap climates get low amounts of snowfall.)* **Which climate region is very cold but not covered by ice?** *(The tundra climate region)*

Apply Have students describe the difficulties of living in ice cap or tundra regions. **learning modality: visual**

Highlands

Teach Key Concepts L2

Highland Climates

Focus Tell students that highland climates can occur within any of the other climate zones.

Teach Ask: **Why are highland climate regions colder than the regions that surround them?** *(Temperature falls as altitude increases.)*

Apply Have students describe the climate-related changes that would occur as one climbs a tall mountain. **learning modality: verbal**

Go Online SCI LINKS NSTA

For: Links on climates of the world
Visit: www.SciLinks.org
Web Code: scn-0942

Polar Climates

The polar climate is the coldest climate region, and includes the ice cap and tundra climates. Ice cap and tundra climates are found only in the far north and south, near the North and South poles. Most polar climates are relatively dry, because the cold air holds little moisture.

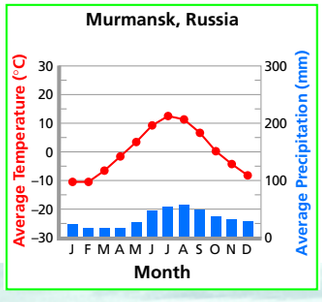
Ice Cap As Figure 10 shows, ice cap climates are found mainly on Greenland and in Antarctica. With average temperatures always at or below freezing, the land in ice cap climate regions is covered with ice and snow. Intense cold makes the air dry. Lichens and a few low plants may grow on the rocks.

Tundra The **tundra** climate region stretches across northern Alaska, Canada, and Russia. Short, cool summers follow bitterly cold winters. Because of the cold, some layers of the tundra soil are always frozen. This permanently frozen tundra soil is called **permafrost.** Because of the permafrost, water cannot drain away, so the soil is wet and boggy in summer.

It is too cold on the tundra for trees to grow. Despite the harsh climate, during the short summers the tundra is filled with life. Mosquitoes and other insects hatch in the ponds and marshes above the frozen permafrost. Mosses, grasses, lichens, wildflowers, and shrubs grow quickly during the short summers. In North America, herds of caribou eat the vegetation and are in turn preyed upon by wolves. Some birds, such as the white-tailed ptarmigan, live on the tundra year-round. Others, such as the arctic tern and many waterfowl, spend only their summer breeding seasons there.

Reading Checkpoint **What type of vegetation is found on the tundra?**

FIGURE 15
Tundra Climate
The Nenet people are reindeer herders on the tundra of northern Russia. These reindeer are grazing on some short shrubs typical of tundra plants.



Highlands

Why are highlands a distinct climate region? **Temperature falls as altitude increases, so highland regions are colder than the regions that surround them.** Increasing altitude produces climate changes similar to the climate changes you would expect with increasing latitude. Precipitation also increases as air masses carrying moisture pass over highland areas.

The climate on the lower slopes of a mountain range is like that of the surrounding countryside. The Rocky Mountain foothills, for instance, share the semi-arid climate of the Great Plains. But as you go higher up into the mountains, temperatures become lower and precipitation increases. Climbing 1,000 meters up in elevation is like traveling 1,200 kilometers toward the poles. The climate higher in the mountains is like that of the subarctic: cool with coniferous trees.

Above a certain elevation—the tree line—temperatures are too low for trees to grow. The climate above the tree line is like that of the tundra. Only low plants, mosses, and lichens can grow there.

FIGURE 16
Highland Climate
Highland climates are generally cooler than surrounding regions. The Mount Rainier area in Washington State has short summers and long, severe winters.
Classifying *What climate zone does the mountaintop resemble?*

Section 2 Assessment

Target Reading Skill **Comparing and Contrasting** Use the information in your table about climate regions to help you answer Question 1.

Reviewing Key Concepts

1. a. **Listing** What two major factors are used to classify climates?
   b. **Reviewing** What other factor did Köppen use in classifying climates?
2. a. **Identifying** What are the six main climate regions?
   b. **Comparing and Contrasting** How is a tropical wet climate similar to a tropical wet-and-dry climate? How are they different?
   c. **Inferring** In what climate region would you find plains covered with short grasses and small bushes? Explain.
   d. **Relating Cause and Effect** Why do marine west coast climates have abundant precipitation?
   e. **Predicting** Which place would have more severe winters—central Russia or the west coast of France? Why?
   f. **Sequencing** Place the following climates in order from coldest to warmest: tundra, subarctic, humid continental, ice cap.
   g. **Relating Cause and Effect** How could a forest grow on a mountain that is surrounded by a desert?

Lab zone At-Home Activity

What's Your Climate? Describe to your family the characteristics of the climate region in which you live. What plants and animals live in your climate region? What characteristics do these plants and animals have that make them well-adapted to the region?

Monitor Progress L2

Answers
Figure 16 Tundra

Reading Checkpoint Mosses, grasses, lichens, wildflowers, and shrubs

Assess

Reviewing Key Concepts

1. a. Temperature and precipitation
b. Vegetation
2. a. Tropical rainy, dry, temperate marine, temperate continental, polar, and highland
b. Both climates are warm. Tropical wet climates receive abundant rainfall all year long, but tropical wet-and-dry climates have wet and dry seasons. **c.** Semiarid, there is not enough rainfall to support trees
d. Prevailing winds carry moisture from the nearby ocean. **e.** Central Russia, it is in a continent's interior. The presence of the nearby ocean and ocean currents moderate the winter temperatures in France. **f.** ice cap, tundra, subarctic, humid continental
g. Precipitation often increases with altitude.

Reteach L1

Use Figure 10 to review the climate regions. Ask students to describe the temperature and precipitation of each. L2

Performance Assessment

Oral Presentation Have students describe the climate region in which they most would like to live.

All in One Teaching Resources

- Section Summary: *Climate Regions*
- Review and Reinforce: *Climate Regions*
- Enrich: *Climate Regions*

Lab zone At-Home Activity

What's Your Climate? L1 Encourage volunteers to identify the climate region in which they live. Help students identify any special characteristics of this climate to which plants and animals must adapt. Encourage students to interview family members about adaptations they have noticed.

Lab zone Consumer Lab

Cool Climate Graphs 12

Prepare for Inquiry

Key Concept

In addition to latitude, factors such as the proximity of large bodies of water, altitude, and the presence of mountains help determine the climate of a region.

Skills Objectives

After this lab, students will be able to

- graph the monthly average precipitation and the monthly average high and low temperatures for a city
- interpret data to identify a city from its climate characteristics

Prep Time 5 minutes
Class Time 40 minutes

Advance Planning

Depending on the level of your students, you might want to distribute copies of graphs with the axes already marked. An overhead transparency of a climate graph will help instruct students about how to make their own graphs.

All in One Teaching Resources

- Lab Worksheet: *Cool Climate Graphs*

Guide Inquiry

Invitation

Ask: **How does climate affect your life?** *(Students should explain that their lifestyle changes with seasonal weather.)* Discuss activities in which students can or cannot participate because of climate considerations.

Lab zone Consumer Lab

Cool Climate Graphs

Problem

Based on climate data, what is the best time of year to visit various cities to enjoy particular recreational activities?

Skills Focus

graphing, interpreting data

Materials

- calculator • ruler • 3 pieces of graph paper
- black, blue, red, and green pencils
- climate map on pages 120–121
- U.S. map with city names and latitude lines

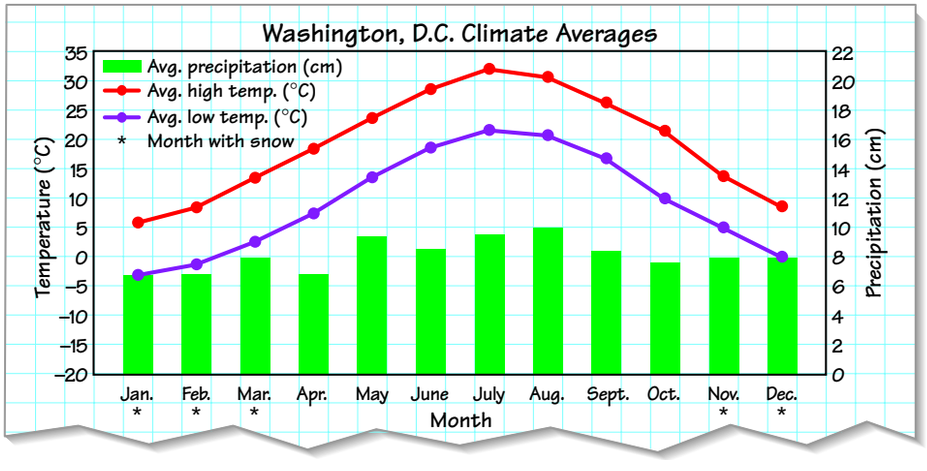
Procedure

1. Work in groups of three. Each person should graph the data for a different city, A, B, or C.
2. On graph paper, use a black pencil to label the axes as on the climate graph below. Title your climate graph City A, City B, or City C.
3. Use your green pencil to make a bar graph of the monthly average amount of precipitation. Place a star below the name of each month that has more than a trace of snow.
4. Use a red pencil to plot the average monthly maximum temperature. Make a dot for the temperature in the middle of each space for the month. When you have plotted data for all 12 months, connect the points into a smooth curved line.
5. Use a blue pencil to plot the average monthly minimum temperature for your city. Use the same procedure as in Step 4.
6. Calculate the total average annual precipitation for this city and include it in your observations. Do this by adding the average precipitation for each month.

Analyze and Conclude

Use all three climate graphs, plus the graph for Washington, D.C., to answer these questions.

1. **Interpreting Data** Which of the four cities has the least change in average temperatures during the year?
2. **Interpreting Maps** Use the map to help find the climate region in which each city is located.



Introduce the Procedure

Instruct students to read the climate graph shown in their text. Discuss the types of data on the graph. Ask: **Why is a climate representation graph useful?** *(A visual picture of monthly temperatures and precipitation makes it easier to compare the climates among different cities.)*

Troubleshooting the Experiment

- Review with students the factors that affect climate.
- Using maps that show the names of cities and the physical geography will help students match their climate graphs with the proper cities.

Climate Data												
Washington, D.C.	**Jan.**	**Feb.**	**Mar.**	**April**	**May**	**June**	**July**	**Aug.**	**Sept.**	**Oct.**	**Nov.**	**Dec.**
Average High Temp. (°C)	6	8	14	19	24	29	32	31	27	21	14	8
Average Low Temp. (°C)	–3	–2	3	8	14	19	22	21	17	10	5	0
Average Precipitation (cm)	6.9	6.9	8.1	6.9	9.4	8.6	9.7	9.9	8.4	7.6	7.9	7.9
Months With Snow	*	*	*	trace	—	—	—	—	—	trace	*	*
City A	**Jan.**	**Feb.**	**Mar.**	**April**	**May**	**June**	**July**	**Aug.**	**Sept.**	**Oct.**	**Nov.**	**Dec.**
Average High Temp. (°C)	13	16	16	17	17	18	18	19	21	21	17	13
Average Low Temp. (°C)	8	9	9	10	11	12	12	13	13	13	11	8
Average Precipitation (cm)	10.4	7.6	7.9	3.3	0.8	0.5	0.3	0.3	0.8	3.3	8.1	7.9
Months With Snow	trace	trace	trace	—	—	—	—	—	—	—	—	trace
City B	**Jan.**	**Feb.**	**Mar.**	**April**	**May**	**June**	**July**	**Aug.**	**Sept.**	**Oct.**	**Nov.**	**Dec.**
Average High Temp. (°C)	5	7	10	16	21	26	29	27	23	18	11	6
Average Low Temp. (°C)	–9	–7	–4	1	6	11	14	13	8	2	–4	–8
Average Precipitation (cm)	0.8	1.0	2.3	3.0	5.6	5.8	7.4	7.6	3.3	2.0	1.3	1.3
Months With Snow	*	*	*	*	*	—	—	—	trace	*	*	*
City C	**Jan.**	**Feb.**	**Mar.**	**April**	**May**	**June**	**July**	**Aug.**	**Sept.**	**Oct.**	**Nov.**	**Dec.**
Average High Temp. (°C)	7	11	13	18	23	28	33	32	27	21	12	8
Average Low Temp. (°C)	–6	–4	–2	1	4	8	11	10	5	1	–3	–7
Average Precipitation (cm)	2.5	2.3	1.8	1.3	1.8	1	0.8	0.5	0.8	1	2	2.5
Months With Snow	*	*	*	*	*	trace	—	—	trace	trace	*	*

3. **Applying Concepts** Which of the cities below matches each climate graph?
   Colorado Springs, Colorado; latitude 39° N
   San Francisco, California; latitude 38° N
   Reno, Nevada; latitude 40° N
4. **Inferring** The four cities are at approximately the same latitude. Why are their climate graphs so different?
5. **Graphing** What factors do you need to consider when setting up and numbering the left and right *y*-axes of a climate graph so that your data will fit on the graph?
6. **Communicating** Imagine that you are writing a travel brochure for one of the four cities. Write a description of the climate of the city and discuss the best time to visit to do a selected outdoor activity.

More to Explore

What type of climate does the area where you live have? Find out what outdoor recreational opportunities your community has. How is each activity particularly suited to the climate of your area?

Expected Outcome

Students will determine the climate type and identity of each city by referring to their climate graphs and U.S. maps.

Analyze and Conclude

1. City A

2. Washington, D.C.: humid subtropical; City A: Mediterranean; City B: semiarid; City C: arid

3. Colorado Springs: City B; San Francisco: City A; Reno: City C

4. Other climate factors, such as distance from large bodies of water, altitude, and mountain ranges, affect the climate of these cities.

5. To set the upper limit for each axis choose a value that is slightly higher than the maximum value of each variable. Then number the axes so that the increments are sufficiently spaced to allow the reader to distinguish the monthly climate data.

6. Brochures should be based on information from the graphs.

Extend Inquiry

More to Explore Help students identify the type of climate in your area and list the recreational opportunities available in and around your community. These might include ice skating, swimming, skiing, golfing, sledding, horseback riding, fishing, picnicking, hiking, camping, biking, cross-country running, and even gardening. Students' explanations of how activities are suited to your area should accurately reflect climate conditions.